one embodiment of the inventive process, the SFDF may be less than about 2, and in one embodiment less than about 1, and in one embodiment less than about 0.5, and in one embodiment less than about 0.2.

[0168] Overall, the shear stress in the microchannel is much higher than the shear stress in a larger channel. The minimum wall shear stress is preferably at least 1 Pa, and more preferably greater than 10 Pa on average for a microchannel.

[0169] Partial boiling allows very good control of the wall temperature between the boiling fluid and the alternate unit operation. The wall is nearly isothermal along its length and is stable to perturbations in process conditions within a process control operating window, including flowrate, inlet temperature, inlet pressure, and others. Many unit operations have advantageous performance from the control brought by partial boiling, including exothermic chemical reactions, distillation, adsorption, absorption, condensation, mixing for emulsions, mixing for increased solubility, and fermentation.

[0170] Exothermic chemical reactions are often plagued by undesired side products that are favored at higher temperatures. As heat is evolved from the primary and desired reaction route it often cannot be removed at the same rate as generated by conventional heat exchange equipment. A faster rate of heat removal through the use of partial boiling allows the exothermic reaction to be operated closer to isothermal and thus reduce the rate of unwanted products. In addition, many exothermic reactions become more equilibrium limited at higher temperature, the water gas shift reaction is one example. A desired outcome is to run the reaction at a higher temperature at the front end of the reactor and at a cooler temperature near the reactor exit. Multiple heat exchange zones may be disposed along the reaction length, whereby each uses partial boiling at a different temperature to reduce the reaction temperature along the length. The exothermic reactions may be either catalytic or homogeneous.

[0171] The reactant, or reactants, and catalyst may be selected for reactions such as: acetylation, addition reactions, alkylation, dealkylation, hydrodealkylation, reductive alkylation, amination, ammoxidation, ammonia synthesis, aromatization, arylation, autothermal reforming, carbonylation, decarbonylation, reductive carbonylation, carboxylation, reductive carboxylation, reductive coupling, condensation, cracking, hydrocracking, cyclization, cyclooligomerization, dehalogenation, dimerization, epoxidation, esterification, exchange, Fischer-Tropsch, halogenation, hydrohalogenation, homologation, hydration, dehydration, hydrogenation, dehydrogenation, hydrocarboxylation, hydroformylation, hydrogenolysis, hydrometallation, hydrosilation, hydrolysis, hydrotreating (HDS/HDN), isomerization, methylation, demethylation, metathesis, nitration, polymerization, reduction, reformation, reverse water gas shift, Sabatier, sulfonation, telomerization, transesterification, trimerization, and water gas shift.

[0172] Distillation is advantaged by careful control of the phase equilibrium temperature within multiple stages along the length of the distillation unit. Partial boiling will allow very nearly isothermal operation in each stage. This will allow the ability to tailor the amount of energy added in each stage to reduce the overall energy input.

[0173] Adsorption, especially thermal swing adsorption, is advantaged by the rapid addition or removal of heat during the desorption and adsorption stages respectively. Partial boiling allows for the desorption staged to be operated more closely to isothermal over the cycle time rather than have a range of temperatures as created by convective heat removal using a fluid. A more isothermal temperature profile during desorption should allow for a higher recovery of the sorbates from the adsorbent and thus an overall higher system efficiency.

[0174] Absorption processes rely on a sorbate solubilizing in a working fluid during absorption before flowing to a desorption unit. The heat of absorption released during fluid uptake is not insignificant and may reduce the overall capacity of the working fluid. Near isothermal operation during absorption would increase the uptake of the absorbate and the system efficiency. In addition, partial boiling during desorption could allow the desorption cycle to operate near isothermal operation and reduce the time required for desorption through efficient heat transfer.

[0175] The conjoined operation of partial boiling and condensation offers advantages of higher heat transfer efficiency and reduced hardware size. Heat integration in commercial chemical plants is an important component of optimizing capital and operating costs. The integrated heat transfer of a condensing and boiling fluid may reduce the need for additional working fluids for each unit operation.

[0176] Exothermic reactions that can be aided by microchannel partial boiling include polymerization reactions. The inventive concepts described can achieve high heat transfer rates over long distances that would be needed for polymer processing. The ability of partial boiling to remove large reactor exotherms seen in the Trommsdorff effect can help suppress the process upsets that make bulk and solution polymerizations dangerous. The Trommsdorff effect is when the polymerization stream sees massive chain growth that results in a large exothermic heat release and the drastic reduction in the chain termination reaction step as a result of viscosity changes. The Trommsdorff effect may leads to a large increase in viscosity of the stream, thereby rendering the stream difficult to pump, as well as leading to large molecular weight polymers that can skew the molecular weight distribution or lead to insoluble pockets in the stream.

[0177] Heat released during mixing may not be insignificant for many fluidic mixtures. As the temperature of the fluid mixture increases the properties may also change, including solubility, phase stability, and thermal and fluidic properties. Removing the heat of mixing with the use of partial boiling will allow for more isothermal operation and tailoring the final fluid mixture properties.

[0178] Fermentation processes are optimized by a more isothermal operation as afforded by partial boiling. Inadequate heat removal raises the temperature during the fermentation process and in turn this may reduce the stability of associated enzymes or yeast or alter the reaction pathways. As an example, the heat released from fermentation during wine making fermentation must be slowed down to preserve the quality of the final product. The ability to remove heat at a faster and more controlled rate with the use of partial boiling could reduce the time required to produce wine from many weeks or months to a few days or less.